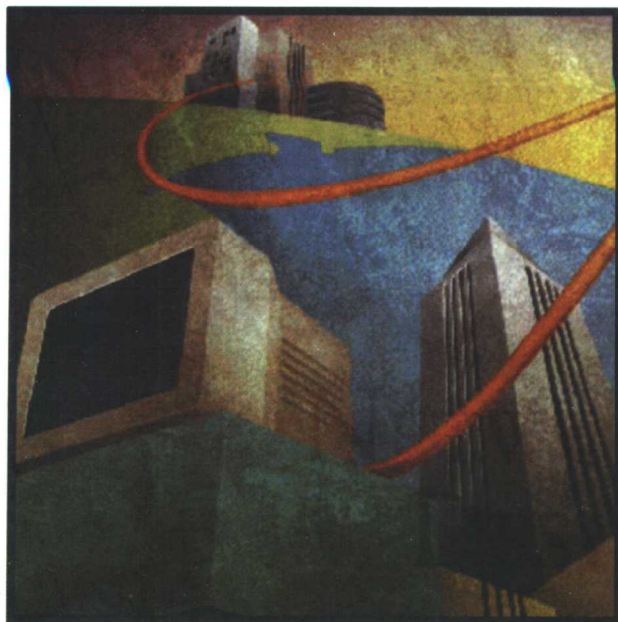CISCO CAREER
CERTIFICATION

C C I E

CISCO CCIE FUNDAMENTALS:

NETWORK DESIGN
AND CASE STUDIES

Authorized preparation materials for CCIE candidates

网络设计与个案分析

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Fundamentals : Network Design and Case Studies

Cisco Systems, Inc.

网络设计与个案分析

Cisco CCIE Fundamentals: Network Design and Case Studies

出 版 前 言

　　21 世纪将会是一个信息高速公路四通八达的时代,信息产业发展的水平亦将是评估一个国家综合国力的重要依据。世界各国将会在信息技术的研究开发和信息产业的发展方面展开激烈的竞争。这既是一种挑战也是一种机遇。有鉴于此,我国已经开始全面快速地发展网络技术和因特网。

　　Cisco Systems 公司是世界领先的全球 Internet,Intranet 以及电信网络设备及解决方案的供应商,1996 年名列世界十大电信公司之一。Cisco Systems 的联网操作系统(IOS)是支持网络服务和网络应用的坚实基础。该公司与麦克米伦计算机出版公司合作创立了 Cisco Press,出版了一系列关于最新的网络技术的权威著作。这些著作不仅兼顾建网与网际互联的基础理论和实际应用,为网络专业人员和用户提供必要的技术支持,还有一部分是为 Cisco CCIE 考试和 CCNA,CCNP,CCDA 及 CCDP 职业考试认证准备的自学和培训教材。Cisco 公司早于 1994 年就进入中国,已为国内信息产业界所熟悉。我们引进其中部分著作组成"CISCO 系列丛书(影印版)"影印出版,以祈对我国信息产业的发展稍尽绵薄之力,并衷心希望这套丛书对从事建网,网际互联的专业人员;有志于我国信息产业发展的读者,以及参加 Cisco 培训和准备 Cisco 考试认证的人员有所裨益。

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About the Authors

Andrea Cheek is currently a documentation manager at an Internet startup company and has worked as a project lead and technical writer for more than twelve years in the telecommunication and networking industries. She worked at Cisco Systems for six years and ROLM systems for five years. She holds a B.A. in English Literature from Stanford University.

H. Kim Lew is a program manager for Cisco Press. He has worked as a writer, course developer, marketing manager, and editorial columnist in the internetworking industry for more than a decade. Since 1990, he has worked at Cisco Systems in various program management, management, and information product development roles. He now telecommutes full-time from Redmond, Washington.

Kathleen Wallace is co-founder of Wallace Technical Communications, an Internet service provider (ISP) serving the small businesses and home office professionals in the San Francisco Bay Area. She has worked as a programmer, staff technical writer, and contract writer for a variety of computing and networking firms, including Apple Computer Inc., Cisco Systems, and National Semiconductor Corporation.

About the Reviewers

Kevin Downes is a Senior Network Systems Consultant with International Network Services (INS). His network certifications include the Cisco CCIE, Bay Networks CRS, Certified Network Expert (CNX) Ethernet, Novell CNE, and Banyan Systems CBE. He has published several articles on the subjects of network infrastructure design, network operating systems (NOS), and Internet Protocol (IP). He completed his B.S. in Computer Information Systems from Strayer University in 1993.

Syed P. Ahmed is a Senior Internetworking Consultant at Cisco Systems, Inc. He has been with Cisco for three years. Prior to Cisco, Mr. Ahmed worked at IBM for eight years as an IBM 3745/NCP Software Developer and VTAM/NCP System Engineer. Prior to IBM, Mr. Ahmed worked at Northern Telecom for eight years as a Senior Product Engineer in DMS 100/200 Switching products and DPN100 Data products. Mr. Ahmed holds a M.Sc. (high honor) from N.C. State in Computer Engineering and a B.Sc. (highest honor) from North Eastern University in Electrical Engineering. He has been a professional engineer since 1979 and a CCIE (Cisco Certified Internetwork Engineer) since 1995. He is a regular contributor to *CCIE Forum* and CCIE/NETWORKERS Seminars at Cisco Systems.

Kris Thompson was raised in Kingston, Ontario where he attended Queen's University Faculty of Applied Science - Electrical Engineering 1988. Ontario P. Eng. 1990. Kris has experience with GM, Bell Canada, NorTel, and Apple and is currently at Cisco Systems, Inc. with Global Support Engineering where he specializes in remote access technologies. Kris is living as a telecommuter on Lake Travis outside Austin, Texas in his new Rammed Earth house. Thanks to my wife Cindy Kosarek.

Foreword

In today's internetworking environment, protocols and services are being added constantly, making it more and more complex to design and implement large-scale networks. The demands for organizations and individuals to maintain and optimally run these networks requires internetworking expertise.

The Cisco Certified Internetwork Expert (CCIE) program has been in the forefront in providing the expertise for the design and implementation of large-scale networks. The basic criteria to design and implement a large-scale network is to have an in-depth knowledge of internetworking protocols and services transported.

Cisco CCIE Fundamentals: Network Design and Case Studies is an excellent CCIE preparation tool that covers in-depth analysis of IP, IBM, IPX, and ISDN protocols. An understanding of all these protocols is required to pass the CCIE exam. The best part about this handbook is that it covers issues such as convergence, route selection, topologies, and design issues. The case studies take these concepts a step further by providing configuration examples.

Please check the CCIE Web page on www.cisco.com for future Cisco Press books.

Imran Qureshi
CCIE Program Manager
Cisco Systems, Inc.

Preface and Acknowledgments

ABOUT THIS BOOK

This publication is directly derived from two existing publications created by Cisco Systems: *Internetwork Design Guide* and *Internetworking Case Studies*. These publications evolved over the course of several years to provide a comprehensive collection of configuration scenarios and design recommendations tailored to the needs of the experienced internetworking specialist. Cisco Press has combined these publications to provide a primer covering many of the technologies and typical implementations encountered by professionals preparing for Cisco Certified Internetwork Expert (CCIE) candidacy.

Although the material provided in this publication was not developed with the *specific* intent of helping professionals achieve CCIE status, it has been used as a foundation guide by many CCIE candidates. It is the first in a series of publications that Cisco Press intends to deliver to prepare IS professionals who are working toward CCIE program completion.

The following discussion provides an author acknowledgment, summarizes the overall objectives, audience, organization, and conventions of *Cisco CCIE Fundamentals: Network Design and Case Studies*, outlines the CCIE program, and introduces plan for Cisco Press support of the CCIE program.

AUTHOR ACKNOWLEDGMENTS

The original Cisco publications *Internetwork Design Guide* and *Internetworking Case Studies* were developed over a period of several years by Andrea Cheek, H. Kim Lew, and Kathleen Wallace. Paula Delay, Donna Kidder, and Diantha Pinner integrated new material into the *Internetwork Design Guide* in the most recent update. An array of subject matter experts and editors contributed to the development of the two source publications during their parallel evolution toward this combined product. Contributors included Rick Fairweather, Bill Kelly, Bill Miskovetz, Morgan Littlewood, Jeff Baher, Jim Grubb, Terri Quinn-Andry, Steve Spanier, Bob Deutsch,

Paulina Knibbe, Adrien Fournier, Kris Thompson, Stuart Hamilton, Phil Byrnes, Bruce Pinsky, Won Lee, George Murickan, Dianna Johansen, and Betsy Fitch. This material was originally assembled to help Cisco network implementers build scalable, reliable, and secure networks. It is with this same intent that Cisco Press brings the combined publication *Cisco CCIE Fundamentals: Network Design and Case Studies* to the general networking community.

DOCUMENT OBJECTIVES

The objective of this publication is to help you identify and implement practical internetworking strategies that are flexible enough to fit a variety of situations and that can also scale as your network requirements change.

Part I, "Internetwork Design," provides a set of general guidelines for planning internetworks and specific suggestions for several key internetworking implementations. Part I focuses on identifying the essential technologies and appropriate implementations for specific environments.

Part II, "Internetworking Case Studies," provides practical examples illustrating how you can implement Cisco Systems software features. Case studies address implementation concerns and show how to apply features. Detailed configuration file examples and network diagrams are included.

This collection of design tips and configuration examples is by no means the final word in internetwork design. Do not try to use this as a step-by-step handbook for designing every facet of your internetwork. Instead, use this publication to help you identify features and capabilities of routers and switches that meet specific internetworking requirements.

AUDIENCE

The design guide portion of this publication is intended to support the network administrator who designs and implements router- or switched-based internetworks. The case study portion of the publication is designed for a similar audience, but focuses on showing practical examples of how to apply Cisco features to meet internetworking needs. Readers should know how to configure a Cisco router and should be familiar with the protocols and media that their routers have been configured to support.

DOCUMENT ORGANIZATION

This document consists of two distinct "parts" and a series of appendixes. Each of these parts and the associated set of appendixes are outlined in the follow descriptions.

Part I: Internetwork Design

Part I, "Internetwork Design," consists of the following 13 chapters, focusing primarily on design strategies and recommendations:

- Chapter 1, "Introduction," provides an overview of the trends and challenges that network designers face today when designing internetworks.

- Chapter 2, "Internetworking Design Basics," provides introductory material that outlines the key issues in designing effective large-scale internetworks, contrasts switching and routing, and describes the three key service layers associated with internetworks: access, distribution, and backbone. The chapter also provides a general mapping of feature capabilities into this hierarchical approach to internetwork design along with a brief overview of the different types of internetworking devices.

- Chapter 3, "Designing Large-Scale IP Internetworks," focuses on routing protocols for large-scale IP internetworks and describes the characteristics of two routing protocols: Enhanced IGRP and Open Shortest Path First (OSPF).

- Chapter 4, "Designing SRB Internetworks," describes the issues that pertain to designing internetworks that use source-route bridging and remote source-route bridging.

- Chapter 5, "Designing SDLC, SDLLC, and QLLC Internetworks," provides information about designing internetworks that use routers in IBM front-end processor (FEP) environments.

- Chapter 6, "Designing APPN Internetworks," describes the issues that pertain to designing internetworks that use APPN.

- Chapter 7, "Designing DLSw+ Internetworks," provides information about designing internetworks that use Data Link Switching Plus (DLSw+).

- Chapter 8, "Designing ATM Internetworks," focuses on the use of Asynchronous Transfer Mode (ATM) technology and LAN Emulation (LANE) in designing WANs.

- Chapter 9, "Designing Packet Service Internetworks," focuses on Frame Relay to describe the implementation of packet-switching services in terms of hierarchical network design, topology, broadcast issues, and performance.

- Chapter 10, "Designing DDR Internetworks," describes the design of dial-on-demand routing (DDR) internetworks. DDR provides connectivity across Public Switched Telephone networks and works with access lists to determine the kinds of packets that initiate a connection.

- Chapter 11, "Designing ISDN Internetworks," describes issues that pertain to designing internetworks that use Integrated Services Digital Network (ISDN) technology. The chapter includes techniques for maximizing performance and minimizing connection costs.

- Chapter 12, "Designing Switched LAN Internetworks," focuses on the operation of LAN switches and compares them with routers. The chapter provides vital information on stability and the use of routers and virtual LANs (VLANs) in switched LAN internetwork designs.

- Chapter 13, "Designing Internetworks for Multimedia," describes the evolution of video and audio capture and compression standards and how these standards affect the way that multimedia applications run in networks today. This chapter shows the transition of a traditional LAN design (capable of handling modest multimedia applications) to switched LAN designs capable of handling bandwidth-intensive multimedia applications.

Part II: Internetworking Case Studies

Part II, "Internetworking Case Studies," consists of 12 chapters, focusing on configuration examples:

- Chapter 14, "RIP and OSPF Redistribution," addresses the issue of integrating Routing Information Protocol (RIP) networks with Open Shortest Path First (OSPF) networks.

- Chapter 15, "Dial-on-Demand Routing," describes Cisco's dial-on-demand (DDR) routing features, which allow you to form wide-area networks (WANs) over existing telephone lines.

- Chapter 16, "Increasing Security on IP Networks," describes Cisco's approach to network security and tells you how to use features of the Cisco IOS software to increase security in Internet Protocol (IP) networks.

- Chapter 17, "Integrating Enhanced IGRP into Existing Networks," describes the use of Enhanced IGRP with three network level protocols: IP, AppleTalk, and Internetwork Packet Exchange (IPX).

- Chapter 18, "Reducing SAP Traffic in Novell IPX Networks," tells you how to use access lists and incremental SAP updates to reduce congestion caused by Service Advertisement Protocol (SAP) updates.

- Chapter 19, "UDP Broadcast Flooding," describes techniques for using directed and flooded UDP broadcasts to deliver incoming data from a few sources to a large number of users in a network that is designed for redundancy.

- Chapter 20, "STUN for Front-End Processors," provides information about configuring serial tunneling (STUN) in traditional Systems Network Architecture (SNA) networks.

- Chapter 21, "Using ISDN Effectively in Multiprotocol Networks," describes the relationship between DDR and ISDN and presents a variety of techniques that can be used to control unnecessary connections in ISDN environments.

- Chapter 22, "Using HSRP for Fault-Tolerant IP Routing," tells you how to use the Hot Standby Routing Protocol (HSRP) to configure a router to assume the IP routing tasks of another router in the event that the other router becomes unavailable.

- Chapter 23, "LAN Switching," describes switching and describes how virtual LANs can be used to control congestion in switched LAN networks.

- Chapter 24, "Multicasting in IP and AppleTalk Networks," provides information about how to configure routers to support multicasting multimedia applications in IP and AppleTalk networks.

- Chapter 25, "Scaling Dial-on-Demand Routing," describes a large asynchronous dial-up network and tells you how to configure it for IP routing.

Appendixes

Cisco CCIE Fundamentals: Network Design and Case Studies concludes with a series of appendixes that support the primary text:

- Appendix A, "Subnetting an IP Address Space," provides a detailed example of subnetting a Class B network.

- Appendix B, "IBM Serial Link Implementation Notes," clarifies some common misconceptions about half-duplex, full-duplex, and multipoint connections.

- Appendix C, "SNA Host Configuration for SRB Networks," describes the configuration of IBM devices, such as FEPs, VTAM-switched major nodes and 3174 cluster controllers, and provides information about configuration values that optimize the device's connection to a router.

- Appendix D, "SNA Host Configuration for SDLC Networks," provides configuration information about FEPs and 3174 cluster controllers in routed SDLC environments.

- Appendix E, "Broadcasts in Switched LANs," presents the results of testing the effect of broadcasts on UNIX, PC, and Macintosh hosts running IP, IPX, and AppleTalk in a flat network topology.

- Appendix F, "References and Recommended Reading," lists books, periodicals, technical publications, and standards that provide additional information that will help you design efficient internetworks.

DOCUMENT CONVENTIONS

This publication uses a number of conventions. Command descriptions use these conventions:

- Examples that contain system prompts denote interactive sessions, indicating that the user enters commands at the prompt. The system prompt indicates the current command mode. For example, the prompt `router(config)#` indicates global configuration mode.

- Commands and keywords are in **boldface** font.

- Arguments for which you supply values are in *italic* font.

- Elements in square brackets ([ ]) are optional.

- Alternative but required keywords are grouped in braces ({ }) and separated by vertical bars (|).

Examples use these conventions:

- Terminal sessions and information the system displays are in screen font.

- Modified configurations show new commands in **boldface** screen font.

- Nonprinting characters, such as passwords, are in angle brackets (< >).

- Default responses to system prompts are in square brackets ([ ]).

- Exclamation points (!) at the beginning of a line indicate a comment line.

CCIE PROGRAM AND CISCO PRESS

Cisco's efforts to facilitate the creation of competent network operations center (NOC) and information systems (IS) staff is exemplified in its Cisco Certified Internetwork Expert (CCIE) program. To support these efforts, Cisco Press is working closely with CCIE program management to create information products that help build the knowledge and expertise of NOC and IS professionals supporting Cisco-based networks. As of this writing, there are three CCIE program certifications:

- CCIE WAN Switching
- CCIE-ISP
- CCIE-Routing and Switching

It is likely that as the networking landscape evolves, the program will evolve to meet the changing needs of networking professionals. It is the intent of Cisco Press to coordinate its efforts to synchronize with changes in the CCIE program. The brief discussions that follow provide an overview of the CCIE program and lab tests and a summary of plans for additional products from Cisco Press that are intended to support CCIE programs.

You can obtain details about the CCIE program directly from Cisco's World Wide Web presence at www.cisco.com.

CCIE Program Description

In becoming the definitive network certification program for Cisco network professionals, the CCIE program provides:

- A definition of "expert-level" technical knowledge and skill
- State-of-the-art methods to evaluate this knowledge and skill
- Enhanced services targeting the needs of these "best in class" engineers

Achieving CCIE status denotes proficiency in supporting diverse internetworks that use routing, bridging, and switching technologies. By passing Cisco's rigorous assessment process, your organization or customers will know that you have passed strict testing and hands-on skill evaluations.

The Cisco Certified Internetwork Expert program certifies individuals, not companies. If you move to another company, your status remains with you as long as you adhere to the program requirements and maintain your certification.

CCIE Certification Laboratory

Internetworking experts agree that written evaluations alone cannot adequately measure an individual's ability to design, implement, or solve problems in a dynamic internetwork.

Proper evaluation of these skills must include hands-on execution that is observed and quantified by an internetworking expert. Cisco has taken this concept to heart by creating the CCIE Certification Lab. Candidates are required to demonstrate competency by:

- Building, configuring, and testing complex internets to provided specifications
- Diagnosing and resolving media, transport, and session problems
- Isolating application-layer problems
- Using packet/frame analysis and Cisco debugging tools
- Documenting and reporting the problem-solving processes used

Candidates are evaluated individually by a senior CCIE internetworking engineer, acting as the lab administrator. Cisco's intent is to make the CCIE Certification Lab as realistic as possible. The lab assessment is currently two full days in length and includes homework.

The CCIE candidate is presented with a complex design to implement from the physical layer, through logical configuration. Candidates are not required to configure any end-user systems, but are responsible for any device residing in the internetwork, including hubs, MAUs, DSU/CSU, and so on. Network specifics, point values, and testing criteria used to assess correctness of the individual configurations are provided.

Upon completion of the implementation, the lab engineer will insert faults in the candidate's internetwork. The candidate must recognize, isolate, document, and resolve each fault. Additionally, the candidate will be required to outline the proper reporting procedures when dealing with the Cisco TAC.

Each configuration scenario and problem has pre-assigned point values. The candidate will strive to gain a minimum aggregate of 80 percent to pass.

Cisco Press CCIE Series

In close coordination with the Cisco CCIE program team, Cisco Press is creating a series of preparation materials aimed at providing up-to-date, accurate information on technologies addressed in the CCIE program. Two basic sets of materials will be developed for distribution via Cisco Press:

- **CCIE Preparation Publication Series**

  Based on CCIE program guidelines from Cisco. This series will be presented as a set of technology-specific volumes.

- **Cisco Certification Courseware Series**

  Based on the Cisco-developed *Introduction to Cisco Router Configuration* (ICRC), *Advanced Cisco Router Configuration* (ACRC), and other key implementation-oriented courses, this series will present course material provided in recommended Cisco-developed, instructor-led classes.

DISCLAIMER

Cisco Systems and Macmillan Computer Publishing make no claims that individual readers will pass any part of CCIE Qualification (Sylvan) tests or CCIE labs. Material presented in Cisco Press publications is not intended to be construed as a replacement for either recommended in-class training or the recommended two years of internetworking field experience. All material is offered as is. Cisco Systems and Macmillan Computer Publishing make no claims as to the effectiveness of information presented.

Contents at a Glance